Bellcomm

955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

date: July 28, 1971

to: Distribution

B71 07044

from: R. J. Stern

subject: Minimum Feasible Sun Elevation for Apollo 16 T+24 Hour Launch Opportunities -- Case 310

ABSTRACT

For the first and third launch months (March and May 1972) of the Apollo 16 time frame, sun elevation angles for T+24 hour launch opportunities in the desirable 17-18 degree range are feasible, satisfying both contingency ΔV and 210-foot antenna PDI coverage requirements. For the second launch month the minimum sun elevation angle satisfying contingency ΔV requirements is approximately 20° and the minimum sun elevation angle satisfying contingency ΔV and the 210-ft. antenna PDI coverage requirements is 23.1°.

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MEMORANDUM FOR FILE

Introduction

Based on current trajectory planning for the Apollo 16 mission to Descartes, the LM viewing angle can be expected to droop to 20° (from a nominal value of 25°) during the descent. It is desirable to maintain at least a two-degree clearance above the sunline for adequate visibility. This condition restricts the sun elevation angle at landing to a maximum of 18°. On T+24 hour launch opportunities such a limit can place stringent performance requirements on the spacecraft.

Results

Minimum feasible sun elevation angles at landing for the T+24 hour launch opportunities of the Apollo 16 mission were determined for a LM approach azimuth of -90° and launch azimuths of 72, 80 and 100°. The results are presented in Table I. In the determination of the minimum sun elevation angles achievable within the SPS performance requirements, LM rescue ΔV capability of 600 ft/sec was the determining factor. Sun elevation ranges satisfying 210-ft. antenna PDI coverage requirements are presented in Figure 1.

It can be seen from Table I that on the basis of SPS performance, the sun elevation can be reduced quite low ($\sim$14.5°) for the first and third months. However, 210-ft. antenna PDI coverage begins at $\sim$17° for these months making the 17-18° range more desirable. For the second launch month, however, the minimum sun elevation angle is 20.3° for a 100° launch azimuth and approximately 20° for a 96° launch azimuth and is outside the range for which 210-ft. antenna PDI coverage is possible.

Discussion and Conclusions

For the T+24 hour launch opportunities in the first and third months of the Apollo 16 mission to Descartes, sun elevation

angles of 17°-18° are feasible satisfying LM descent visibility requirements, as well as contingency ΔV and 210-ft. antenna PDI coverage requirements.

For the second month two options may be possible. The minimum sun elevation value of 20° can be chosen resulting in no 210-ft. antenna PDI coverage and requiring modifications in the LM descent trajectory to achieve a minimum viewing angle of approximately 22°. Alternately the sun elevation could be increased to 23.1° to achieve PDI coverage and the LM descent trajectory modified to achieve a minimum viewing angle of 25°.

The reduction of the droop in the trajectory may result in a variable LPD reading with time as opposed to a nearly constant PDI reading over a large portion of the trajectory for a droop of approximately 5° (Reference 1). Increasing the viewing angle at high gate results in greater required ΔV for the descent, reduced visibility time and less redesignation capability (Reference 2).

R. J. Stern

2013-RJS-jab

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Attachments

REFERENCES

1. Parameter Sensitivities of Preliminary Apollo 15 Trajectories, Memorandum for File B70-12082, Case 310, J. A. Sorensen, December 31, 1970.

2. Preliminary Study of Steep LM Descent Trajectories Suitable for a One-Day Launch Delay, Memorandum for File B70-12058, Case 310, C. M. Cauwels, J. A. Sorenson, December 21, 1970.

TABLE I: MINIMUM SUN ELEVATION ANGLES FOR APOLLO 16
T+24 HOUR LAUNCH OPPORTUNITIES - DESCARTES

APPROACH AZIMUTH = -90°

T+24 Hour Launch Opportunity	Launch Azimuth (Deg.)	Sun Elevation is Contrained to be:
3/18/72	72	>12.5° by the LM Rescue Requirement
	80	>13.2° " " " " "
	100	>14.5° " " " " "
4/17/72	72	>18.0° " " " " "
	80	>18.7 " " " " "
	100	>20.3° " " " " "
5/16/72	72	>12.3° " " " " "
	80	>12.75° " " " " "
	100	>14.2° " " " " "

TABLE II: MISSION INDEPENDENT ΔV'S AND WEIGHT MODEL

Event	ΔV (fps)	LM Rescue Weight drop (lbs)	Weather Avoidance Weight drop (lbs)
Launch	0.	173.5	173.5
Hybrid maneuver	0.	0.	0.
Mid-course correction	23.	385.0	385.0
LOI	0.	67.3	67.3
DOI	0.	649.8	649.8
CSM circularization	0.	117.7	117.7
CSM plane change	0.	288.9	245.7
LM rescue	0.	216.	0.
Rendezvous	0.	-170.6	-170.6
Bootstrap maneuver	0.	0.	0.
TEI	0.	276.2	194.7
Weather avoidance burn	0.	0.	95.9

	LM Rescue	Weather Avoidance
SPS Fuel Usable =	39,667	39,695
CSM Inert =	27,245	27,217
SLA =	4,100	4,100
LM =	36,312	36,312
Injected Weight =	107,324	107,324

SPS ISP = 314.4

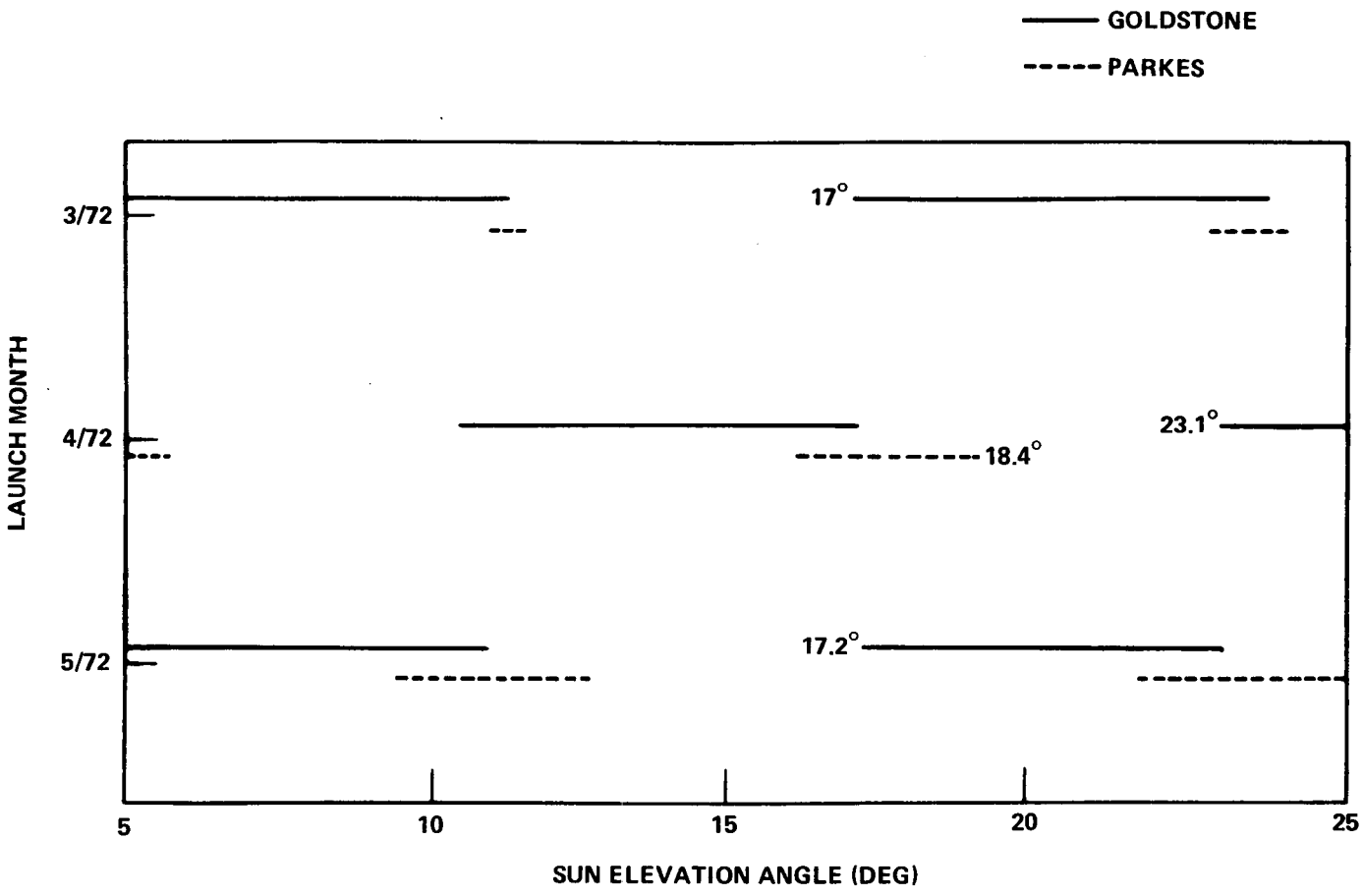

FIGURE 1 - 210-FT. ANTENNA PDI COVERAGE FOR DESCARTES